

```
In [ ]: import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
```

```
In [ ]: martabase = pd.read_csv("martabase_final.csv")
```

```
In [ ]: martabase.head()
```

```
Out[ ]:
```

	ID	Station	Latitude	Longitude	Color
0	1	Airport	33.640758	-84.446341	NaN
1	2	Arts Center	33.789705	-84.387789	NaN
2	3	Ashby	33.756346	-84.417556	NaN
3	4	Avondale	33.775277	-84.281903	NaN
4	5	Bankhead	33.771890	-84.428840	NaN

```
In [ ]: martabase.shape
```

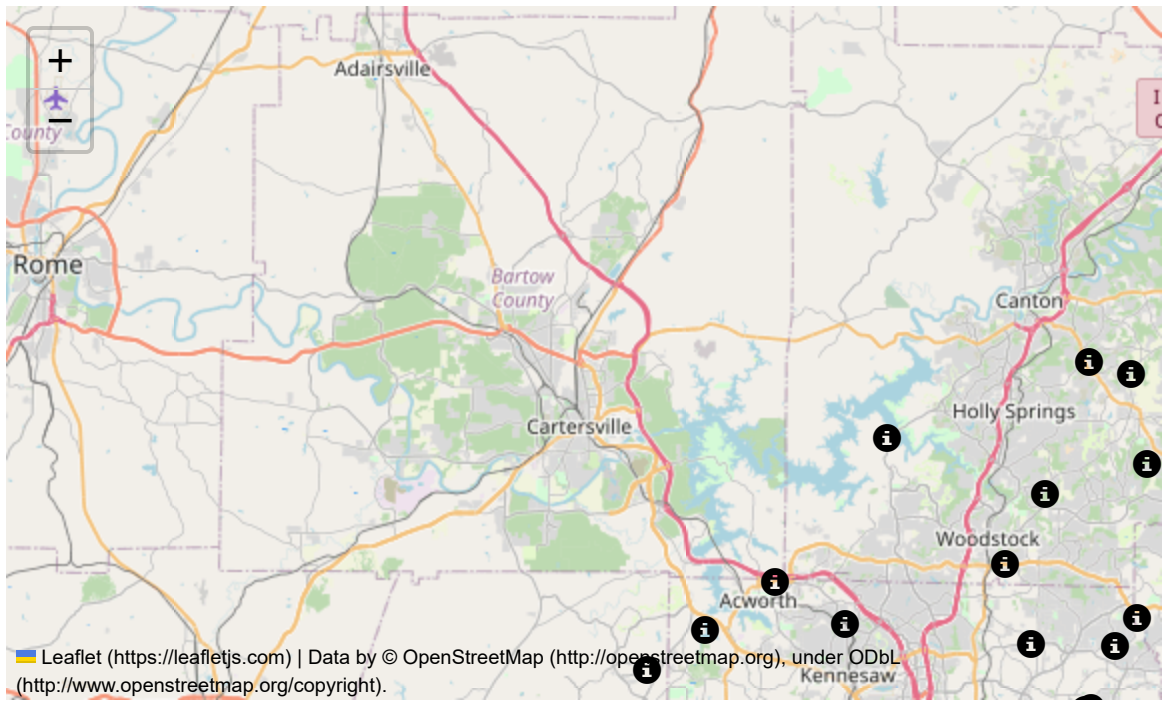
```
Out[ ]: (160, 5)
```

```
In [ ]: import folium

mapmarta=folium.Map(location=[33.934150, -84.246706])

for ind in range(len(martabase["Station"])):
    name = martabase.iloc[ind,1]
    lat = martabase.iloc[ind,2]
    longi = martabase.iloc[ind,3]
    folium.Marker([lat,longi],tooltip=name, icon=folium.Icon(color='black',icon_col
mapmarta
```

Out[ ]:



```
In [ ]: from collections import defaultdict

class Graph:
    def __init__(self, vertices):
        self.V = vertices
        self.graph = defaultdict(list)

    def addEdge(self, v1, v2):
        self.graph[v1].append(v2)
        self.graph[v2].append(v1)

    def DepthFirst(self, v, visited_list):
        visited_list[v] = True
        for i in self.graph[v]:
            if visited_list[i] == False:
                self.DepthFirst(i, visited_list)

    def isConnected(self):
        visited_list = False*(self.V)
        for i in range(self.V):
            if len(self.graph[i]) != 0:
                break
        if i == self.V-1:
            return True

        self.DepthFirst(i, visited_list)

        # Check if all non-zero degree vertices are visited
        for i in range(self.V):
            if visited_list[i] == False and len(self.graph[i]) > 0:
                return False

        return True
```

```

def isEulerian(self):
    # Check if all non-zero degree vertices are connected
    if self.isConnected() == False:
        return 0
    else:
        # Count vertices with odd degree
        odd = 0
        for i in range(self.V):
            if len(self.graph[i]) % 2 != 0:
                odd += 1
        #number of odds:
        # 0 -> euler cycle
        # 2 -> euler path
        # >2 -> not eulerian
        if odd == 0:
            return 2 #euler cycle
        elif odd == 2:
            return 1 #euler path
        elif odd > 2:
            return 0 #no euler

def test(self):
    res = self.isEulerian()
    if res == 0:
        print("Graph is not Eulerian")
    elif res == 1:
        print("Graph has a Euler path")
    else:
        print("Graph has a Euler cycle")

```

```

In [ ]: g = Graph(160)
        g.addEdge(1,2)

```

```

In [ ]: names = martabase.iloc[:,1]
        latitudes = martabase.iloc[:,2]
        longitudes = martabase.iloc[:,3]
        longitudes.head()

```

```

Out[ ]: 0    -84.446341
        1    -84.387789
        2    -84.417556
        3    -84.281903
        4    -84.428840
        Name: Longitude, dtype: float64

```

```

In [ ]: npnames = names.to_numpy()
        nplats = latitudes.to_numpy()
        nplongs = longitudes.to_numpy()

```

```

In [ ]: from sklearn.preprocessing import MinMaxScaler

        nplats = nplats.reshape(-1, 1)
        nplongs = nplongs.reshape(-1, 1)

```

```
lats_fin = MinMaxScaler().fit_transform(nplats)
longs_fin = MinMaxScaler().fit_transform(nplongs)
```

```
In [ ]: lats_fin[0]
```

```
Out[ ]: array([0.06162806])
```

```
In [ ]: longs_fin[0]
```

```
Out[ ]: array([0.37190522])
```

```
In [ ]: longs = longs_fin.flatten()
lats = lats_fin.flatten()
```

```
In [ ]: vertices_finnn = pd.DataFrame({'Station': npnames, 'Latitude': lats, 'Longitude': longs})
martagraph = vertices_finnn.set_index('Station')[['Longitude', 'Latitude']].apply(lambda x: x[0] - x[1], axis=1)
```

```
In [ ]: vertices_f = martabase.iloc[:,2:4]
vertices_f.head()
```

```
Out[ ]:
   Latitude  Longitude
0  33.640758 -84.446341
1  33.789705 -84.387789
2  33.756346 -84.417556
3  33.775277 -84.281903
4  33.771890 -84.428840
```

```
In [ ]: import numpy as np
import networkx as nx
import matplotlib.pyplot as plt
import math
```

```
In [ ]: vertices_final = vertices_f.to_numpy().tolist()
vertices_final[0]
```

```
Out[ ]: [33.640758, -84.446341]
```

```
In [ ]: def distance_formula(x1, y1, x2, y2):
    dist = math.sqrt( (math.pow( (x1 - x2) ,2)) + (math.pow( (y1 - y2) ,2)) )
    return dist

def knn_edges(n, k, vertices):
    edges = []
    for key, v in vertices.items():
        # Values for x1,x2
        name = key
        y1 = v[0]
        x1 = v[1]
```

```
# Calculate distances to other vertices
distances = []
for key2, u in vertices.items():
    if u[0]!=y1 and u[1]!=x1:
        try:
            distances.append((u, distance_formula(x1, y1, u[1], u[0])))
        except Exception as e:
            print(f"Error calculating distance: {e}")

# Sort distances
distances.sort(key=lambda x: x[1])

# Select k nearest neighbors and add edges
for j in range(k):
    u, _ = distances[j]
    val = {i for i in martagraph if martagraph[i]==u}
    va = val.pop()
    edges.append((name, va, distances[j][1]))

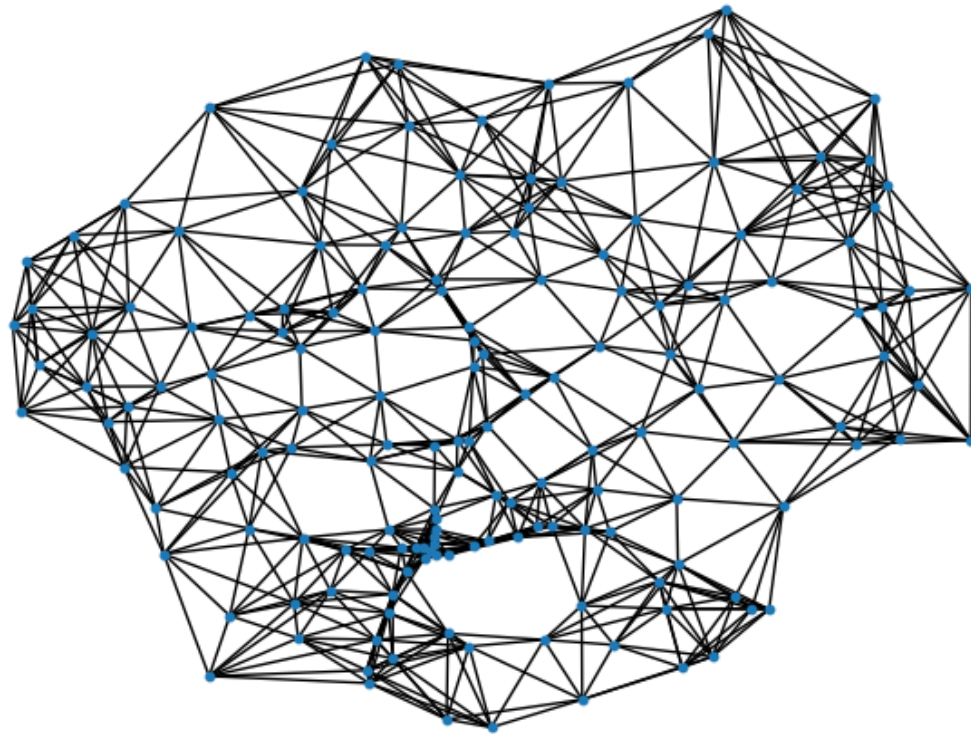
return edges

G = nx.Graph()

# Step 3: Add nodes and edges
for name, coordinates in martagraph.items():
    G.add_node(name, pos=coordinates) # Add node with 'pos' attribute

edges = knn_edges(160, 8, martagraph)
#print(edges)
G.add_weighted_edges_from(edges)

# Plot the graph
pos = nx.get_node_attributes(G, 'pos')
nx.draw(G, pos, with_labels=False, node_size=10)
plt.show()
```



```
In [ ]: for k in range(20):
        G2 = nx.Graph()

        # Step 3: Add nodes and edges
        for name, coordinates in martagraph.items():
            G2.add_node(name, pos=coordinates) # Add node with 'pos' attribute

        edges = knn_edges(160, k, martagraph)
        G2.add_weighted_edges_from(edges)
        try:
            eulerian_circuit = list(nx.eulerian_circuit(G))
            # Print the Eulerian circuit
            print("Eulerian Circuit:", eulerian_circuit)

            # Visualize the graph and the Eulerian circuit
            pos = nx.spring_layout(G2)
            nx.draw(G2, pos, with_labels=True, font_weight='bold')
            nx.draw_networkx_edges(G2, pos, edgelist=eulerian_circuit, edge_color='r',
                                  plt.show())
        except Exception as e:
            print(f"Error not Eulerian: {e}")
```

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Error not Eulerian: G is not Eulerian.
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```
In [ ]: '''def hamiltonian(graph, start, path=[]):
    path = path + [start]
    if len(path) == len(graph.nodes):
        return path
    for node in graph.neighbors(start):
        if node not in path:
            new_path = hamiltonian(graph, node, path)
            if new_path:
                return new_path
    return None

starting_node = list(G.nodes)[0]

hamiltonian_path = hamiltonian(graph=G, start=starting_node)

print("Hamiltonian Path:", hamiltonian_path)
'''

# Visualize the graph and the Hamiltonian path
'''
pos = nx.spring_layout(G)
nx.draw(G, pos, with_labels=True, font_weight='bold')
nx.draw_networkx_nodes(G, pos, nodelist=hamiltonian_path, node_color='r')
nx.draw_networkx_edges(G, pos, edgelist=[(hamiltonian_path[i], hamiltonian_path[i +
plt.show()
'''
```

```
Out[ ]: "\npos = nx.spring_layout(G)\nnx.draw(G, pos, with_labels=True, font_weight='bol
d')\nnx.draw_networkx_nodes(G, pos, nodelist=hamiltonian_path, node_color='r')\nn
x.draw_networkx_edges(G, pos, edgelist=[(hamiltonian_path[i], hamiltonian_path[i +
1]) for i in range(len(hamiltonian_path) - 1)], edge_color='r', width=2)\nplt.show
()\"
```

```
In [ ]: Ge = nx.euler.eulerize(G)

eulerian_circuit = list(nx.eulerian_circuit(Ge))
```

```
# Print the Eulerian circuit
print("Eulerian Circuit:", eulerian_circuit)

# Visualize the graph and the Eulerian circuit
pos = nx.get_node_attributes(Ge, 'pos')
nx.draw(Ge, pos, with_labels=False, node_size=12)
nx.draw_networkx_edges(Ge, pos, edgelist=eulerian_circuit, edge_color='r', width=1.
plt.show()
```



Eulerian Circuit: ['Airport', 'City of South Fulton Station'], ('City of South Fulton Station', 'Cascade Springs'), ('Cascade Springs', 'Deerwood Park'), ('Deerwood Park', 'Melvin Drive Park'), ('Melvin Drive Park', 'Cascade Springs'), ('Cascade Springs', 'Sandtown'), ('Sandtown', 'Melvin Drive Park'), ('Melvin Drive Park', 'Sweetwater Creek State Park'), ('Sweetwater Creek State Park', 'Lions Park'), ('Lions Park', 'Woodrow Willson Park'), ('Woodrow Willson Park', 'Hurt Road Park'), ('Hurt Road Park', 'Lions Park'), ('Lions Park', 'Heritage Park'), ('Heritage Park', 'Bishop Park'), ('Bishop Park', 'Cheatham Hill '), ('Cheatham Hill ', 'Mud Creek'), ('Mud Creek', 'Bishop Park'), ('Bishop Park', 'Wild Horse'), ('Wild Horse', 'Woodrow Willson Park'), ('Woodrow Willson Park', 'Heritage Park'), ('Heritage Park', 'Standing Peachtree Park'), ('Standing Peachtree Park', 'Palisades Unit'), ('Palisades Unit', 'Sope Creek '), ('Sope Creek ', 'Morgan Falls'), ('Morgan Falls', 'Gold Branch Trail'), ('Gold Branch Trail', 'East Cobb Park'), ('East Cobb Park', 'Morgan Falls'), ('Morgan Falls', 'Downtown Roswell'), ('Downtown Roswell', 'North Roswell'), ('North Roswell', 'Hickory Flat'), ('Hickory Flat', 'Hobgood Park'), ('Hobgood Park', 'Tomahawk'), ('Tomahawk', 'North Roswell'), ('North Roswell', 'West Field'), ('West Field', 'Morgan Falls'), ('Morgan Falls', 'Horseshoe Bend '), ('Horseshoe Bend ', 'Jones Bridge Park'), ('Jones Bridge Park', 'Horseshoe Bend '), ('Horseshoe Bend ', 'Gold Branch Trail'), ('Gold Branch Trail', 'Sope Creek '), ('Sope Creek ', 'East Cobb Park'), ('East Cobb Park', 'Downtown Marietta'), ('Downtown Marietta', 'Bishop Park'), ('Bishop Park', 'Hurt Road Park'), ('Hurt Road Park', 'Mud Creek'), ('Mud Creek', 'Wild Horse'), ('Wild Horse', 'Hurt Road Park'), ('Hurt Road Park', 'Silver Comet Trail'), ('Silver Comet Trail', 'Palisades Unit'), ('Palisades Unit', 'West Buckhead'), ('West Buckhead', 'Standing Peachtree Park'), ('Standing Peachtree Park', 'Silver Comet Trail'), ('Silver Comet Trail', 'Lions Park'), ('Lions Park', 'Smyrna'), ('Smyrna', 'Lions Park'), ('Lions Park', 'Old Clarkdale Park'), ('Old Clarkdale Park', 'Mud Creek'), ('Mud Creek', 'Oregon Park'), ('Oregon Park', 'Allatoona Creek Park'), ('Allatoona Creek Park', 'Cheatham Hill '), ('Cheatham Hill ', 'Downtown Marietta'), ('Downtown Marietta', 'East Marietta'), ('East Marietta', 'Sope Creek '), ('Sope Creek ', 'Wheeler'), ('Wheeler', 'Downtown Marietta'), ('Downtown Marietta', 'East Marietta'), ('East Marietta', 'East Cobb Park'), ('East Cobb Park', 'Wheeler'), ('Wheeler', 'Sandy Plains'), ('Sandy Plains', 'Hobgood Park'), ('Hobgood Park', 'Noonday'), ('Noonday', 'Hickory Flat'), ('Hickory Flat', 'Tomahawk'), ('Tomahawk', 'Noonday'), ('Noonday', 'East Cobb Park'), ('East Cobb Park', 'West Field'), ('West Field', 'Gold Branch Trail'), ('Gold Branch Trail', 'Downtown Roswell'), ('Downtown Roswell', 'Horseshoe Bend '), ('Horseshoe Bend ', 'Peachtree Corners'), ('Peachtree Corners', 'Gwinnett Village/GACS'), ('Gwinnett Village/GACS', 'Mountain Park'), ('Mountain Park', 'Briscoe Park'), ('Briscoe Park', 'Yellow River Park'), ('Yellow River Park', 'Collinsville'), ('Collinsville', 'Flat Rock'), ('Flat Rock', 'Village Park'), ('Village Park', 'Kennedy Memorial Gardens'), ('Kennedy Memorial Gardens', 'Lake Charlotte Preserve'), ('Lake Charlotte Preserve', 'Browns Mill Park'), ('Browns Mill Park', 'Kennedy Memorial Gardens'), ('Kennedy Memorial Gardens', 'Chapel Hill Park'), ('Chapel Hill Park', 'Village Park'), ('Village Park', 'Exchange Park'), ('Exchange Park', 'Kennedy Memorial Gardens'), ('Kennedy Memorial Gardens', 'West Stonecrest'), ('West Stonecrest', 'Exchange Park'), ('Exchange Park', 'Chapel Hill Park'), ('Chapel Hill Park', 'Flat Rock'), ('Flat Rock', 'West Stonecrest'), ('West Stonecrest', 'Collinsville'), ('Collinsville', 'East Stonecrest'), ('East Stonecrest', 'West Stonecrest'), ('West Stonecrest', 'Chapel Hill Park'), ('Chapel Hill Park', 'Arabia Mountain'), ('Arabia Mountain', 'Village Park'), ('Village Park', 'Lake Charlotte Preserve'), ('Lake Charlotte Preserve', 'Browns Mill Park'), ('Browns Mill Park', 'Lake City'), ('Lake City', 'Lake Charlotte Preserve'), ('Lake Charlotte Preserve', 'Forest Park'), ('Forest Park', 'Village Park'), ('Village Park', 'Lake City'), ('Lake City', 'Kennedy Memorial Gardens'), ('Kennedy Memorial Gardens', 'The Meadows'), ('The Meadows', 'Collinsville'), ('Collinsville', 'Arabia Mountain'), ('Arabia Mountain', 'East Stonecrest'), ('East Stonecrest', 'Flat Rock'), ('Flat R

ock', 'The Meadows'), ('The Meadows', 'Chapel Hill Park'), ('Chapel Hill Park', 'Redan'), ('Redan', 'Exchange Park'), ('Exchange Park', 'The Meadows'), ('The Meadows', 'East Stonecrest'), ('East Stonecrest', 'Yellow River Park'), ('Yellow River Park', 'Mountain Park'), ('Mountain Park', 'Bryson Park'), ('Bryson Park', 'McDaniel Farm'), ('McDaniel Farm', 'Gwinnett Village/GACS'), ('Gwinnett Village/GACS', 'Mountain Park'), ('Mountain Park', 'West Snellville'), ('West Snellville', 'Yellow River Park'), ('Yellow River Park', 'Redan'), ('Redan', 'Yellow River Park'), ('Yellow River Park', 'Central Snellville'), ('Central Snellville', 'Mountain Park'), ('Mountain Park', 'Stone Mountain'), ('Stone Mountain', 'Yellow River Park'), ('Yellow River Park', 'Lithonia'), ('Lithonia', 'Flat Rock'), ('Flat Rock', 'Arabia Mountain'), ('Arabia Mountain', 'West Stonecrest'), ('West Stonecrest', 'The Meadows'), ('The Meadows', 'Arabia Mountain'), ('Arabia Mountain', 'Redan'), ('Redan', 'Arabia Mountain'), ('Arabia Mountain', 'Lithonia'), ('Lithonia', 'Collinsville'), ('Collinsville', 'Redan'), ('Redan', 'East Stonecrest'), ('East Stonecrest', 'Lithonia'), ('Lithonia', 'West Stonecrest'), ('West Stonecrest', 'Redan'), ('Redan', 'Lithonia'), ('Lithonia', 'The Meadows'), ('The Meadows', 'Kensington'), ('Kensington', 'Exchange Park'), ('Exchange Park', 'Avondale'), ('Avondale', 'Exchange Park'), ('Exchange Park', 'Indian Creek'), ('Indian Creek', 'The Meadows'), ('The Meadows', 'Redan'), ('Redan', 'Stone Mountain'), ('Stone Mountain', 'Northlake'), ('Northlake', 'North Druid Hills'), ('North Druid Hills', 'Emory'), ('Emory', 'Northlake'), ('Northlake', 'Bryson Park'), ('Bryson Park', 'Gwinnett Village/GACS'), ('Gwinnett Village/GACS', 'Berkeley Lake'), ('Berkeley Lake', 'Jones Bridge Park'), ('Jones Bridge Park', 'Peachtree Corners'), ('Peachtree Corners', 'McDaniel Farm'), ('McDaniel Farm', 'Sugarloaf'), ('Sugarloaf', 'Lawrenceville'), ('Lawrenceville', 'Collins Hill Park'), ('Collins Hill Park', 'Lawrenceville'), ('Lawrenceville', 'Gwinnett Airport'), ('Gwinnett Airport', 'Sugarloaf'), ('Sugarloaf', 'Collins Hill Park'), ('Collins Hill Park', 'South Buford'), ('South Buford', 'Buford Exchange'), ('Buford Exchange', 'Gwinnett Airport'), ('Gwinnett Airport', 'Mall of Georgia'), ('Mall of Georgia', 'Gwinnett Airport'), ('Gwinnett Airport', 'Collins Hill Park'), ('Collins Hill Park', 'Buford Exchange'), ('Buford Exchange', 'Mall of Georgia'), ('Mall of Georgia', 'Collins Hill Park'), ('Collins Hill Park', 'Dacula'), ('Dacula', 'Buford Exchange'), ('Buford Exchange', 'Lawrenceville'), ('Lawrenceville', 'North Snellville'), ('North Snellville', 'Briscoe Park'), ('Briscoe Park', 'Grayson'), ('Grayson', 'Gwinnett Airport'), ('Gwinnett Airport', 'North Snellville'), ('North Snellville', 'Grayson'), ('Grayson', 'West Snellville'), ('West Snellville', 'Briscoe Park'), ('Briscoe Park', 'Lilburn'), ('Lilburn', 'West Snellville'), ('West Snellville', 'North Snellville'), ('North Snellville', 'Dacula'), ('Dacula', 'Grayson'), ('Grayson', 'Lawrenceville'), ('Lawrenceville', 'Dacula'), ('Dacula', 'Grayson'), ('Grayson', 'Central Snellville'), ('Central Snellville', 'North Snellville'), ('North Snellville', 'Lilburn'), ('Lilburn', 'Gwinnett Village/GACS'), ('Gwinnett Village/GACS', 'Tucker'), ('Tucker', 'Mountain Park'), ('Mountain Park', 'Lilburn'), ('Lilburn', 'McDaniel Farm'), ('McDaniel Farm', 'Berkeley Lake'), ('Berkeley Lake', 'Bryson Park'), ('Bryson Park', 'Lilburn'), ('Lilburn', 'West Lawrenceville'), ('West Lawrenceville', 'Lilburn'), ('Lilburn', 'Central Snellville'), ('Central Snellville', 'Briscoe Park'), ('Briscoe Park', 'Loganville'), ('Loganville', 'Dacula'), ('Dacula', 'Mall of Georgia'), ('Mall of Georgia', 'South Buford'), ('South Buford', 'Big Creek'), ('Big Creek', 'Fowler Park'), ('Fowler Park', 'Bell Memorial Park'), ('Bell Memorial Park', 'Tomahawk'), ('Tomahawk', 'West Field'), ('West Field', 'Downtown Roswell'), ('Downtown Roswell', 'Alpharetta'), ('Alpharetta', 'Fowler Park'), ('Fowler Park', 'Cumming'), ('Cumming', 'Bell Memorial Park'), ('Bell Memorial Park', 'North Roswell'), ('North Roswell', 'Alpharetta'), ('Alpharetta', 'Bell Memorial Park'), ('Bell Memorial Park', 'Big Creek'), ('Big Creek', 'Cumming'), ('Cumming', 'East Johns Creek'), ('East Johns Creek', 'Big Creek'), ('Big Creek', 'Sugar Hill'), ('Sugar Hill', 'Cumming'), ('Cumming', 'Buford'), ('Buford', 'Big Creek'), ('Big Creek', 'Suwanee'), ('Suwanee', 'Cumming'), ('Cumming', 'South Buford'), ('South Buford', 'East Johns Creek'), ('East

Johns Creek', 'Fowler Park'), ('Fowler Park', 'Johns Creek'), ('Johns Creek', 'Alpharetta'), ('Alpharetta', 'Jones Bridge Park'), ('Jones Bridge Park', 'North Point'), ('North Point', 'Bell Memorial Park'), ('Bell Memorial Park', 'Hickory Flat'), ('Hickory Flat', 'Woodstock'), ('Woodstock', 'North Roswell'), ('North Roswell', 'North Point'), ('North Point', 'Downtown Roswell'), ('Downtown Roswell', 'East Cobb'), ('East Cobb', 'Wheeler'), ('Wheeler', 'East Marietta'), ('East Marietta', 'Cheatham Hill '), ('Cheatham Hill ', 'Oregon Park'), ('Oregon Park', 'Roxana'), ('Roxana', 'Allatoona Creek Park'), ('Allatoona Creek Park', 'Wildwood'), ('Wildwood', 'Oregon Park'), ('Oregon Park', 'Mt Tabor Park'), ('Mt Tabor Park', 'Wildwood'), ('Wildwood', 'Roxana'), ('Roxana', 'Mt Tabor Park'), ('Mt Tabor Park', 'Allatoona Creek Park'), ('Allatoona Creek Park', 'Lost Mountain Park'), ('Lost Mountain Park', 'Wildwood'), ('Wildwood', 'Powder Creek Crossing'), ('Powder Creek Crossing', 'Oregon Park'), ('Oregon Park', 'Lake Lucile'), ('Lake Lucile', 'Roxana'), ('Roxana', 'Powder Creek Crossing'), ('Powder Creek Crossing', 'Roxana'), ('Roxana', 'Lost Mountain Park'), ('Lost Mountain Park', 'Mud Creek'), ('Mud Creek', 'Lake Lucile'), ('Lake Lucile', 'Mt Tabor Park'), ('Mt Tabor Park', 'Powder Creek Crossing'), ('Powder Creek Crossing', 'Wild Horse'), ('Wild Horse', 'Lake Lucile'), ('Lake Lucile', 'Powder Creek Crossing'), ('Powder Creek Crossing', 'Lost Mountain Park'), ('Lost Mountain Park', 'Oregon Park'), ('Oregon Park', 'Lost Mountain Park'), ('Lost Mountain Park', 'Wild Horse'), ('Wild Horse', 'Old Clarkdale Park'), ('Old Clarkdale Park', 'Sweetwater Creek State Park'), ('Sweetwater Creek State Park', 'Old Clarkdale Park'), ('Old Clarkdale Park', 'Hurt Road Park'), ('Hurt Road Park', 'Heritage Park'), ('Heritage Park', 'Silver Comet Trail'), ('Silver Comet Trail', 'Westminister'), ('Westminister', 'Palisades Unit'), ('Palisades Unit', 'Marietta/Lockheed'), ('Marietta/Lockheed', 'Sope Creek '), ('Sope Creek ', 'Kennesaw State Univ'), ('Kennesaw State Univ', 'East Cobb Park'), ('East Cobb Park', 'Sandy Plains'), ('Sandy Plains', 'West Field'), ('West Field', 'Noonday'), ('Noonday', 'Sandy Plains'), ('Sandy Plains', 'Noonday'), ('Noonday', 'Acworth'), ('Acworth', 'Lost Mountain Park'), ('Lost Mountain Park', 'Cheatham Hill '), ('Cheatham Hill ', 'Kennesaw State Univ'), ('Kennesaw State Univ', 'Bishop Park'), ('Bishop Park', 'Kennesaw State Univ'), ('Kennesaw State Univ', 'Sandy Plains'), ('Sandy Plains', 'East Cobb'), ('East Cobb', 'Gold Branch Trail'), ('Gold Branch Trail', 'Sandy Springs'), ('Sandy Springs', 'Sope Creek '), ('Sope Creek ', 'North Springs'), ('North Springs', 'Gold Branch Trail'), ('Gold Branch Trail', 'Dunwoody'), ('Dunwoody', 'Gold Branch Trail'), ('Gold Branch Trail', 'Roswell'), ('Roswell', 'Jones Bridge Park'), ('Jones Bridge Park', 'Johns Creek'), ('Johns Creek', 'Peachtree Corners'), ('Peachtree Corners', 'Berkeley Lake'), ('Berkeley Lake', 'Sugarloaf'), ('Sugarloaf', 'West Lawrenceville'), ('West Lawrenceville', 'Grayson'), ('Grayson', 'Loganville'), ('Loganville', 'Central Snellville'), ('Central Snellville', 'West Snellville'), ('West Snellville', 'Loganville'), ('Loganville', 'North Snellville'), ('North Snellville', 'West Lawrenceville'), ('West Lawrenceville', 'Dacula'), ('Dacula', 'Gwinnett Airport'), ('Gwinnett Airport', 'West Lawrenceville'), ('West Lawrenceville', 'Loganville'), ('Loganville', 'Lawrenceville'), ('Lawrenceville', 'West Lawrenceville'), ('West Lawrenceville', 'Collins Hill Park'), ('Collins Hill Park', 'Sugar Hill'), ('Sugar Hill', 'East Johns Creek'), ('East Johns Creek', 'Buford'), ('Buford', 'Buford Exchange'), ('Buford Exchange', 'Sugar Hill'), ('Sugar Hill', 'Mall of Georgia'), ('Mall of Georgia', 'Buford'), ('Buford', 'Sugar Hill'), ('Sugar Hill', 'South Buford'), ('South Buford', 'Buford'), ('Buford', 'Suwanee'), ('Suwanee', 'Mall of Georgia'), ('Mall of Georgia', 'East Duluth'), ('East Duluth', 'South Buford'), ('South Buford', 'Suwanee'), ('Suwanee', 'East Johns Creek'), ('East Johns Creek', 'Johns Creek'), ('Johns Creek', 'Berkeley Lake'), ('Berkeley Lake', 'East Duluth'), ('East Duluth', 'Buford Exchange'), ('Buford Exchange', 'Suwanee'), ('Suwanee', 'Collins Hill Park'), ('Collins Hill Park', 'East Duluth'), ('East Duluth', 'Sugar Hill'), ('Sugar Hill', 'Suwanee'), ('Suwanee', 'East Johns Creek'), ('East Johns Creek', 'East Duluth'), ('East Duluth', 'Suwanee'), ('Suwanee', 'Sugarloaf'), ('Sugarloaf', 'East Duluth'), ('East Duluth', 'Johns Creek'),

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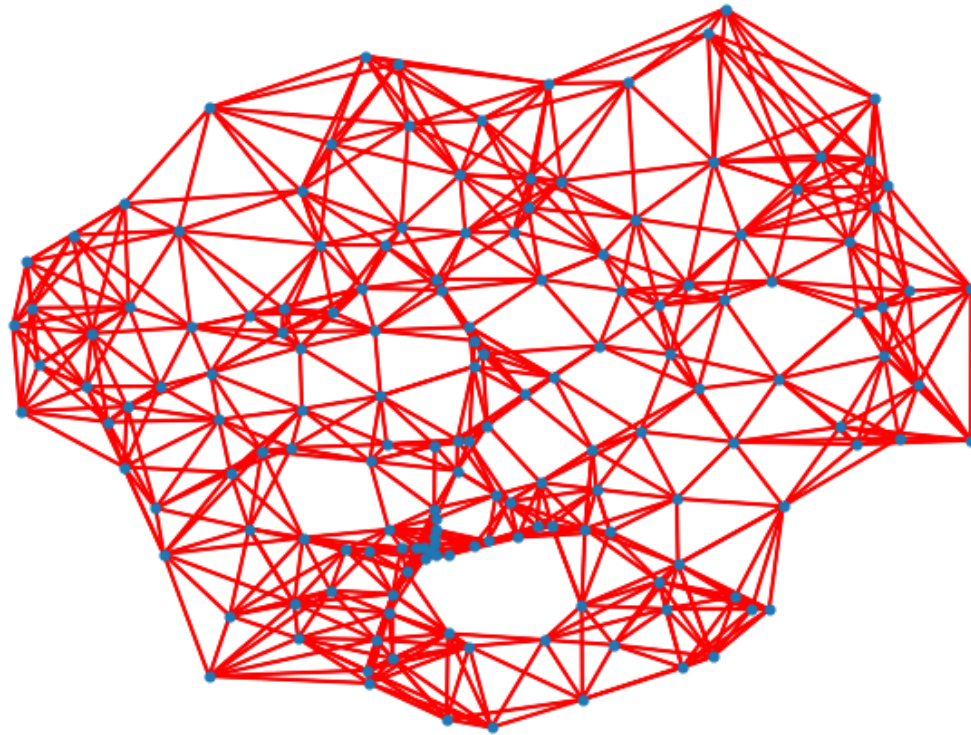
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Mill Park'), ('Browns Mill Park', 'East Point'), ('East Point', 'City of South Fulton Station'), ('City of South Fulton Station', 'College Park'), ('College Park', 'Lake Charlotte Preserve'), ('Lake Charlotte Preserve', 'Airport'), ('Airport', 'Lake City'), ('Lake City', 'College Park'), ('College Park', 'Oakland City'), ('Oakland City', 'Lakewood/Fort McPherson'), ('Lakewood/Fort McPherson', 'Garnett'), ('Garnett', 'West Lake'), ('West Lake', 'Five Points'), ('Five Points', 'Midtown'), ('Midtown', 'Five Points'), ('Five Points', 'West End'), ('West End', 'Garnett'), ('Garnett', 'Vine City'), ('Vine City', 'Georgia State'), ('Georgia State', 'Inman Park/Reynoldstown'), ('Inman Park/Reynoldstown', 'Peachtree Center'), ('Peachtree Center', 'Georgia State'), ('Georgia State', 'North Avenue'), ('North Avenue', 'Five Points'), ('Five Points', 'Inman Park/Reynoldstown'), ('Inman Park/Reynoldstown', 'King Memorial'), ('King Memorial', 'Georgia State'), ('Georgia State', 'Garnett'), ('Garnett', 'King Memorial'), ('King Memorial', 'Five Points'), ('Five Points', 'Garnett'), ('Garnett', 'Peachtree Center'), ('Peachtree Center', 'Five Points'), ('Five Points', 'Georgia State'), ('Georgia State', 'Edgewood/Candler Park'), ('Edgewood/Candler Park', 'Emory'), ('Emory', 'East Lake'), ('East Lake', 'King Memorial'), ('King Memorial', 'Edgewood/Candler Park'), ('Edgewood/Candler Park', 'Inman Park/Reynoldstown'), ('Inman Park/Reynoldstown', 'East Lake'), ('East Lake', 'Edgewood/Candler Park'), ('Edgewood/Candler Park', 'Decatur'), ('Decatur', 'Inman Park/Reynoldstown'), ('Inman Park/Reynoldstown', 'Civic Center'), ('Civic Center', 'Edgewood/Candler Park'), ('Edgewood/Candler Park', 'North Avenue'), ('North Avenue', 'GWCC/CNN Center'), ('GWCC/CNN Center', 'King Memorial'), ('King Memorial', 'Civic Center'), ('Civic Center', 'Georgia State'), ('Georgia State', 'GWCC/CNN Center'), ('GWCC/CNN Center', 'West Lake'), ('West Lake', 'H. E. Holmes'), ('H. E. Holmes', 'Ashby'), ('Ashby', 'Adamsville'), ('Adamsville', 'Bankhead'), ('Bankhead', 'Standing Peachtree Park'), ('Standing Peachtree Park', 'Arts Center'), ('Arts Center', 'CDC'), ('CDC', 'Lenox'), ('Lenox', 'Westminister'), ('Westminister', 'Buckhead'), ('Buckhead', 'Lindbergh Center'), ('Lindbergh Center', 'Lenox'), ('Lenox', 'West Buckhead'), ('West Buckhead', 'Buckhead'), ('Buckhead', 'Medical Center'), ('Medical Center', 'Brookhaven/Oglethorpe'), ('Brookhaven/Oglethorpe', 'Lindbergh Center'), ('Lindbergh Center', 'Arts Center'), ('Arts Center', 'West Buckhead'), ('West Buckhead', 'Brookhaven/Oglethorpe'), ('Brookhaven/Oglethorpe', 'Chamblee'), ('Chamblee', 'Lenox'), ('Lenox', 'Buckhead'), ('Buckhead', 'Brookhaven/Oglethorpe'), ('Brookhaven/Oglethorpe', 'Lenox'), ('Lenox', 'Brookhaven/Oglethorpe'), ('Brookhaven/Oglethorpe', 'North Druid Hills'), ('North Druid Hills', 'Avondale'), ('Avondale', 'Emory'), ('Emory', 'Decatur'), ('Decatur', 'Kensington'), ('Kensington', 'Avondale'), ('Avondale', 'East Lake'), ('East Lake', 'Decatur'), ('Decatur', 'Avondale'), ('Avondale', 'Edgewood/Candler Park'), ('Edgewood/Candler Park', 'Peachtree Center'), ('Peachtree Center', 'GWCC/CNN Center'), ('GWCC/CNN Center', 'Five Points'), ('Five Points', 'Vine City'), ('Vine City', 'GWCC/CNN Center'), ('GWCC/CNN Center', 'Midtown'), ('Midtown', 'Civic Center'), ('Civic Center', 'GWCC/CNN Center'), ('GWCC/CNN Center', 'West End'), ('West End', 'Ashby'), ('Ashby', 'H. E. Holmes'), ('H. E. Holmes', 'Bankhead'), ('Bankhead', 'Peachtree Center'), ('Peachtree Center', 'Civic Center'), ('Civic Center', 'Vine City'), ('Vine City', 'Bankhead'), ('Bankhead', 'North Avenue'), ('North Avenue', 'Civic Center'), ('Civic Center', 'Five Points'), ('Five Points', 'Ashby'), ('Ashby', 'West Lake'), ('West Lake', 'Bankhead'), ('Bankhead', 'GWCC/CNN Center'), ('GWCC/CNN Center', 'Garnett'), ('Garnett', 'Ashby'), ('Ashby', 'Peachtree Center'), ('Peachtree Center', 'Arts Center'), ('Arts Center', 'GWCC/CNN Center'), ('GWCC/CNN Center', 'Ashby'), ('Ashby', 'Bankhead'), ('Bankhead', 'Civic Center'), ('Civic Center', 'Arts Center'), ('Arts Center', 'North Avenue'), ('North Avenue', 'Arts Center'), ('Arts Center', 'Bankhead'), ('Bankhead', 'Midtown'), ('Midtown', 'Arts Center'), ('Arts Center', 'Vine City'), ('Vine City', 'Ashby'), ('Ashby', 'Oakland City'), ('Oakland City', 'East Point'), ('East Point', 'Lakewood/Fort McPherson'), ('Lakewood/Fort McPherson', 'Hapeville'), ('Hapeville', 'East Point'), ('East Point', 'Deerwood Park'), ('Deerwood Park', 'College Park'), ('College Park', 'Browns Mill Park'), ('B

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lege Park', 'East Point'), ('East Point', 'Airport'), ('Airport', 'Hapeville'),
('Hapeville', 'College Park'), ('College Park', 'Airport')]

```



```

In [ ]: # example path provided by app from Avalon to Airport station using weighted Dijkstra
lp = True
while lp:
    try:
        start = input("Enter your starting location: ")
        end = input("Enter your destination: ")
        print(nx.dijkstra_path(G, start, end))
        lp = False
    except Exception as e:
        print(f"Error: {e}")

```

Error: Node io not found in graph

```

['Avalon', 'North Point', 'Horseshoe Bend ', 'North Springs', 'Medical Center', 'Buckhead', 'Lindbergh Center', 'Arts Center', 'Vine City', 'West End', 'Lakewood/Fort McPherson', 'Airport']

```

```

In [ ]: for u, v, data in G.edges(data=True):
        if 'weight' not in data:
            G[u][v]['weight'] = 0.05
        #print(f"Edge ({u}, {v}): {data}")

```

```

In [ ]: import torch
import torch.nn as nn

```

```
import torch.optim as optim
import torch_geometric
import tensorflow as tf

# Convert your NetworkX graph to a PyTorch Geometric Data object
node_features = torch.randn(160, 16)
data = torch_geometric.utils.from_networkx(G)
data.x = node_features
print(data)

# Define and train a GNN model
class GNN(torch.nn.Module):
    def __init__(self, input_size, hidden_size, output_size):
        super(GNN, self).__init__()
        self.conv1 = torch_geometric.nn.GraphConv(input_size, hidden_size)
        self.conv2 = torch_geometric.nn.GraphConv(hidden_size, output_size)

    def forward(self, x, edge_index):
        x = self.conv1(x, edge_index)
        x = torch.relu(x)
        x = self.conv2(x, edge_index)
        return x

model = GNN(input_size=16, hidden_size=64, output_size=2)
optimizer = optim.Adam(model.parameters(), lr=0.01)
criterion = nn.CrossEntropyLoss()

# Train the model on your graph data
for epoch in range(20):
    optimizer.zero_grad()
    output = model(data.x, data.edge_index)
    target = torch.ones_like(output)
    loss = criterion(output, target)
    loss.backward()
    optimizer.step()

    print(f'Epoch {epoch + 1}/{20}, Loss: {loss.item()}')

# uses the learned embeddings to guide Hamiltonian path search
node_embeddings = model.conv1(data.x, data.edge_index)
print(node_embeddings)
```



```

Data(edge_index=[2, 1540], pos=[159, 2], weight=[1540], x=[160, 16])
Epoch 1/20, Loss: 3.6754250526428223
Epoch 2/20, Loss: 7.075736045837402
Epoch 3/20, Loss: 4.351600170135498
Epoch 4/20, Loss: 5.848458290100098
Epoch 5/20, Loss: 3.195577621459961
Epoch 6/20, Loss: 3.5237343311309814
Epoch 7/20, Loss: 4.00560998916626
Epoch 8/20, Loss: 2.653991937637329
Epoch 9/20, Loss: 2.611069917678833
Epoch 10/20, Loss: 3.016585350036621
Epoch 11/20, Loss: 2.355003833770752
Epoch 12/20, Loss: 2.118072032928467
Epoch 13/20, Loss: 2.5813546180725098
Epoch 14/20, Loss: 2.4784207344055176
Epoch 15/20, Loss: 1.8085826635360718
Epoch 16/20, Loss: 1.8909556865692139
Epoch 17/20, Loss: 2.1892223358154297
Epoch 18/20, Loss: 1.8698699474334717
Epoch 19/20, Loss: 1.697495460510254
Epoch 20/20, Loss: 1.9151763916015625
tensor([[ 1.2764, -0.0851,  4.0211, ...,  0.6951, -0.8406, -1.1633],
        [ 0.5514,  0.5048,  1.0761, ..., -0.4511, -0.9251,  1.0614],
        [ 2.7418, -4.4167,  2.8022, ..., -1.3299, -2.9913, -3.1469],
        ...,
        [ 0.1665,  1.2033, -1.5127, ...,  0.8876, -0.6083,  0.1930],
        [ 3.8695,  0.4998,  1.3280, ..., -0.4611,  1.4111, -2.7711],
        [-0.5052,  0.2717,  1.0724, ..., -0.5386,  0.3535, -1.3361]],
        grad_fn=<AddBackward0>)

```